MORPHOLOGY OF TWO RARE MEDITERRANEAN GOBIID FISHES (TELEOSTEI: GOBIIDAE)

by

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ABSTRACT. - The Mediterranean gobiids *Didogobius splechtnai* and *Gammogobius steinitzi* occur sympatrically in submerged caves at the Balearic Island of Ibiza (Western Mediterranean). Both species inhabit the dark backgrounds of large caves, *G. steinitzi* mainly the walls and *D. splechtnai* the sediment-covered bottoms. Morphological characters like body proportions, meristics, the lateral-line system and osteological features are described and compared.

RÉSUMÉ. - Morphologie de deux gobies rares de Méditerranée (Teleostei: Gobiidae).

Les gobies méditerranéens *Didogobius splechtnai* et *Gammogobius steinitzi* sont présents dans les grottes sous-marines de l'île Ibiza (Baléares, Méditerranée occidentale). Ces deux espèces se trouvent principalement dans les zones obscures des grottes. *G. steinitzi* préférant les parois et *D. splechtnai* les fonds couverts de sédiments. Les caractères morphologiques (proportions corporelles), méristiques, ostéologiques et du système latéral sont décrits et comparés.

Key-words. - Gobiidae, *Didogobius splechtnai*, *Gammogobius steinitzi*, MED, Balearic Islands, Lateral-line system, Osteology.

Didogobius splechtnai Ahnelt & Patzner, 1995 and *Gammogobius steinitzi* Bath, 1971 occur sympatrically in submerged caves at the Balearic Island of Ibiza in 4-18 m and 4-43 m depth respectively, where they occupy different microhabitats (Ahnelt and Patzner, 1996; Herler *et al.*, in press).

Both species were described for the first time based on a few specimens only and little is known for example about the possible variability of the lateral-line system and of osteological features. Additional samples from the type locality (*D. splechtnai*) and from other localities in the Western Mediterranean (*G. steinitzi*) (Ahnelt *et al.*, 1998) allow a more detailed description of several morphological characteristics. Type-specimens of *G. steinitzi* were included in this study, revealing that this species was originally described on the basis of two species from two genera (Scsepka and Ahnelt, in press).

Within Atlantic-Mediterranean gobiids, small body size and cryptobenthic life is apparently often combined with reductions (e.g., in the lateral-line system, loss of scale ctenii) which are regarded as morphological specializations (Miller, 1966, 1977). The aim of this study is to compare morphological features, especially of the lateral-line system and the osteology, of the two sympatric cave-dwelling gobiids *D. splechtnai* and *G. steinitzi*.

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METHODS AND ABBREVIATIONS

Meristics

A: anal fin; C: caudal fin (branched rays); D1, D2 : first and second dorsal fins; LL: scales in lateral series; P: pectoral fin; TR: scales in transversal series; V: pelvic disc.

Morphometrics

Follows Miller and Smith (1989).

Ab, anal fin base; Ad, Aw, body depth and width at anal fin origin; Cl, caudal fin length; CHd, cheek depth; CP, CPd, caudal peduncle length and depth; d, damaged; D1b, D2b, first and second dorsal fin bases; E, eye diameter; H, Hw, head length and width; I, interorbital width; Pl, pectoral fin length; PO, postorbital length; SL, standard length; SN, snout length; SN/A, SN/AN, distance from snout to vertical of anal fin origin and anus; SN/D1, SN/D2, distance from snout to origin of first and second dorsal fins; SN/V, distance from snout to vertical of pelvic spinous ray origin; TL, total length; UJ, upper jaw length; V/AN, distance from origin of pelvic spinous ray (V I) to anus; Vd, body depth at origin of V I; Vl, distance from V I origin to tip of longest pelvic ray. Size is given in SL + Cl.

Osteology

Terminology follows Springer (1983) and Murdy (1985).

AC, anterior ceratohyal; AN, retroarticular; ART, anguloarticular; BR, branchiostegal rays; CL, cleithrum; COR, coracoid; D, dentary; ER, epipleural rib; EPU, epural plate; HH, hypohyal; HS, hemal spine; HY, hyomandibular; HYP, hypural plate; IH, interhyal; IOP, interopercle; MPT, metapterygoid; MX, maxilla; NS, neural spine; OP, opercle; PAL, palatine; PC, posterior ceratohyal; PHYP, parhypural; PMX, premaxilla; POP, preopercle; PR, pleural rib; PT, pterygiophore; PTG, ectopterygoid; PTM, posttemporal; QU, quadrate; RAD, radials; SCA, scapula; SCL, supracleithrum; SOP, subopercle; SY, symplectic; VT1 to VT27, vertebra 1 to 27.

For the examination of the osteology, one male and one female of each species was cleared and stained (Dingerkus and Uhler, 1977). Specimens were not disarticulated or dissected, description of the hyoid is therefore incomplete, as the tiny dorsal and ventral hypohyals are not clearly determinable.

Lateral-line system

Terminology follows Sanzo (1911) and Miller (1986).

Canals: AOS, POS, anterior and posterior oculoscapular canals; POC, preopercular canal. Pores are marked with Greek lettering.

Series of sensory papillae (free neuromasts): AD, anterior dorsal; OP, opercular; OS, oculoscapular; PM, preopercular-mandibular; por, papillae of the inner preopercular series, lying between the imaginary pores of POC if latter is absent; PO, preorbital; SO, suborbital.

Institutions

NMW, Naturhistorisches Museum Wien.

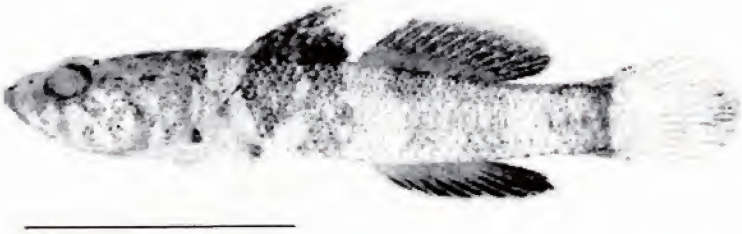

Fig. 1. - *Didogobius splechtnai*, IZUW 4100:20, female, 22.0 + 5.5 mm, Spain; Ibiza, Punta Mares; 8m; 21 Sep. 1997. Scale bar = 10 mm.

DIDOGOBIUS SPLECHTNAI AHNELT & PATZNER, 1995

(Fig. 1)

Material

18 specimens: 10 males, 7 females, 1 juvenile.

Spain, Balearic Islands, north coast of Ibiza near Portinatx, submarine caves:

Punta Xaracca, 11 m depth, 1 male, 23.2 + 6.6 mm, NMW 94450, 19 May 1997; 11 m depth, 1 male, 26.2 + 6.8 mm, IZUW 4100:25, 27 Sep. 1997. Punta Mares, 7 m depth, 1 juvenile, 12.4 + 3.5 mm, IZUW 4100:1, 26 Sep. 1994; 9 m depth, 1 female, 20.3 + 5.8 mm, IZUW 4100:10, 12 m depth, 1 female, 22.0 + 5.6 mm, IZWU 4100:9, Aug. 1995; 4 m depth, 1 female, 27.8 + 7.3 mm, NMW 94451, 20. May 1997, 8 m depth, 1 female, 22.0 + 5.5 mm, IZUW 4100:20, 21 Sep. 1997. Cala Xaracca, 18 m depth, 1 male, 19.1 + 5.4 mm, IZUW 4100:12, Sep. 1995. Punta Galera 17.5 m depth, 1 male, 18.4 + 5.0 mm, IZUW 4100:11, 16.5 m depth, 1 male, 16.9 + 4.6 mm, IZUW 4100:14, 1 female, 18.9 + 5.0 mm, IZUW 4100:13, Aug. 1995. The specimens are deposited at the Institut für Zoologie der Universität Wien, except those with NMW register numbers.

For type material (5 males and 2 females), see Ahnelt and Patzner (1995).

General description

Didogobius splechtnai differs from all other Mediterranean gobiids in the combination of the following characters: (1) anterior nostril tubular, reaching lower lip when depressed; no process from rim, (2) AOS present; POS absent; POC present, reduced or absent, (3) six transversal suborbital rows; 4 rows before, one above and one below b; rows 1, 2, 3 and 5 before longitudinal row b; row 5 long, nearly reaches row d; row 6 divided by b into 6s and 6i; row 7 represented by one papilla near pore α, (4) longitudinal row d continuous and (5) head, predorsal area and breast naked; body with cycloid and ctenoid scales.

Urogenital papilla in females with small papillae; similar in males, more elongated and less fringed.

Sexual dimorphism exists in abdomen length, head length and upper jaw length. Body proportions are given in table I.

Fins

D1 VI (18); D2 I/10 (18); A I/9 (18); C 14-16 (14:7, 15:9, 16:1, d:1); P 15-16 (15:17, 16:1); V I/5+5/I (18).

D1 spines becoming progressive shorter in both sexes; interdorsal space narrow; A originates posterior of vertical through D2 origin; C truncated; uppermost rays of P not free from membrane; V somewhat emarginate, ray 5 shorter than ray 4 and originates below origin of P; poorly developed fraenum.

Table I. - Body proportions of *Didogobius splechtnai* from Ibiza. Values are ranges, means (m) and standard deviations (s).

Sex		Males			Females		
n		10			7		
SL (mm)		16.9-26.2			18.9-27.8		
		ranges	m	s	ranges	m	s
%SL	H	32.1-35.4	34.1	1.0	31.6-33.5	32.6	0.7
	Hw	14.0-16.6	14.7	0.7	13.6-17.6	15.2	1.2
	SN/D1	38.1-42.7	40.7	1.4	37.8-40.8	39.2	1.1
	SN/D2	57.3-61.6	59.3	1.4	56.4-59.2	57.7	1.0
	SN/AN	54.3-58.1	56.2	1.2	55.1-58.7	56.4	1.3
	SN/A	58.2-62.7	60.7	1.3	59.6-63.1	61.0	1.2
	SN/V	28.8-32.9	31.0	1.2	28.4-33.0	30.6	1.7
	CP	22.1-25.0	23.5	0.8	22.3-24.7	23.5	0.8
	D1b	12.1-13.9	12.9	0.6	11.5-13.4	12.7	0.7
	D2b	22.1-24.7	23.4	0.9	23.7-27.0	24.8	1.0
	Ab	17.2-20.1	18.3	1.0	18.6-20.6	19.4	0.6
	Cl	24.2-29.4	27.5	1.5	25.0-28.7	26.1	1.2
	Pl	24.2-31.5	28.6	1.9	25.7-32.2	29.9	2.3
	Vl	25.3-29.5	27.8	1.4	26.1-31.0	27.9	1.5
	Vd	15.4-17.3	16.4	0.7	16.0-18.4	17.3	0.8
	Ad	14.4-15.7	15.1	0.3	15.0-17.6	16.2	0.8
	Aw	7.4-9.8	8.5	0.7	8.0-11.6	10.0	1.1
	CPd	10.6-11.3	11.0	0.2	10.7-12.6	11.6	0.6
	V/AN	24.4-29.1	26.3	1.5	25.7-27.9	27.1	0.7
% CP	CPd	44.8-50.2	46.8	1.4	44.8-54.7	49.4	3.6
% H	SN	23.3-27.0	24.8	1.3	24.1-27.0	25.4	1.0
	E	24.4-26.9	25.9	0.8	24.0-26.8	25.5	0.9
	PO	51.0-54.3	52.7	1.2	51.3-54.1	52.7	1.0
	CHd	16.1-19.0	17.3	0.8	15.5-21.1	18.0	1.6
	Hw	39.9-49.8	43.1	2.7	42.9-54.2	46.7	3.8
	UJ	28.3-31.5	29.8	0.8	27.7-32.0	31.0	1.4
% E	I	18.7-24.7	22.2	1.9	21.4-29.2	24.9	2.9
% V/AN	Vl	87.7-117.1	105.8	8.7	93.5-112.5	103.0	5.7

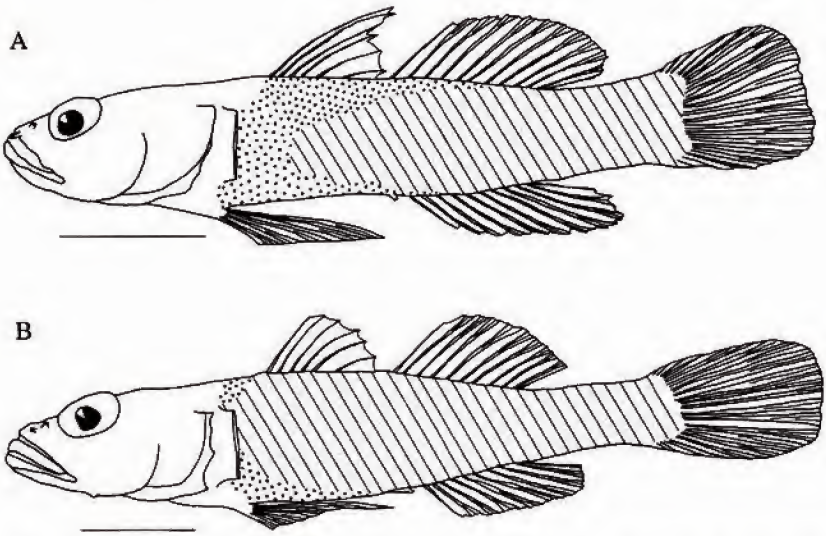

Fig. 2. - *Didogobius splechtnai* (**A**) and *Gammogobius steinitzi* (**B**). Dotted areas cycloid and hatched areas ctenoid scales. Scale bar = 5 mm.

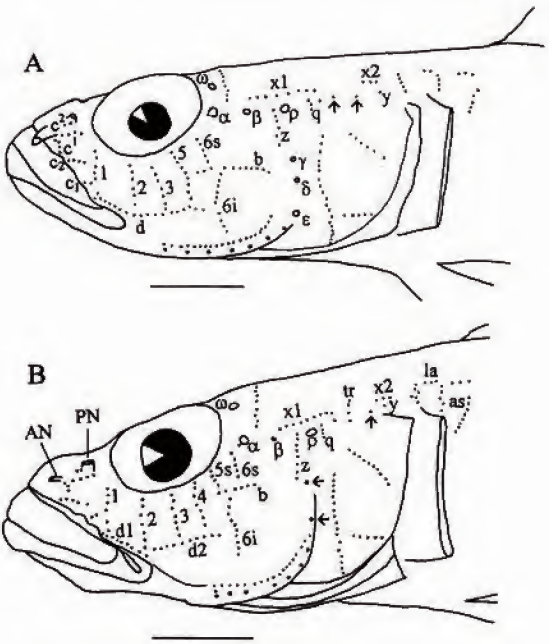

Fig. 3. - Lateral view of head lateral-line sensory papillae and canal pores (Greek lettering) of (**A**) *Didogobius splechtnai*, NMW 94451, female, 27.8 + 7.3 mm, Spain, Ibiza, 20 May 1997 and (**B**) *Gammogobius steinitzi*, IZUW 3300:11, female, 24.9 + 5.9 mm, Spain, Ibiza, 15 May 1997. AN, PN: anterior and posterior nostrils; horizontal arrows: u; vertical arrows: por. Scale bar = 2 mm.

Scales (Fig. 2A)

Mostly ctenoid; cycloid scales forming a continuous area, dorsal from P origin to D1 origin and rearwards to approximately half of D2b (to D2 6 - D2 9), ventral from P origin across ventral side of abdomen to A. Head, predorsal area and breast naked. LL 30-31 (30:8, 31:10), TR 9-10 (9:5, 10:13).

Coloration of preserved specimens (Fig. 1)

Snout and circumorbital area dark; dark bands and speckles on cheek and gill-cover. Dark blotch in rear corner of D1 membrane. D2 and A rays light; fin membranes pigmented, with transparent rims. C light; P light, with dark spots on dorsal and ventral base, dark tips; V rays and membrane pale.

Otherwise as in Ahnelt and Patzner (1995).

Table II. - Numbers of sensory papillae in head lateral-line system of *Didogobius splechtnai* and *Gammogobius steinitzi* from Ibiza.

Didogobius splechtnai **SL 16.9 - 27.8 mm n = 16 (* n = 17)**			***Gammogobius steinitzi*** **SL 21.7 - 35.8 mm n = 10 (* n = 9)**			***Didogobius splechtnai***			***Gammogobius steinitzi***		
	left	**right**		**left**	**right**		**left**	**right**		**left**	**right**
PO			**PO**			**OS**			**OS**		
r	2-5	3-5	r	3-5	3-5	x1	7-10	6-9	x1	9-11	8-12
s1	3-6	2-5	s1	3-5	3-5	x2	1-3	2-4	x2	3-5	3-5
s2	1-3	1-3	s2	4-6	3-6	z	5-9	5-9	z	7-10	6-10
s3	2-4	2-4	s3	3-5	3-5*	q	1-4	1-4	q	3-5	3-5
c^2	6-9*	6-9	c^2	6-8	5-10	y	1	1	y	1-2	1-2
c^1	1-4	3-4	c^1	3-4	2-4	tr	1	1	tr	3-6	3-6
c_2	3-5	3-5	c_2	5-7	5-7	u	2	2	u	1-2	1-3
c_1	1-3	2-3	c_1	2-3	2-3	as1	2-6	3-7	as1	5-8	6-8
SO			**SO**			as2	2-5	3-5	as2	4-7	4-7
1	6-8	6-8	1	6-9	5-9	as3	4-6	3-7	as3	6-10	6-12
2	4-7	5-8	2	5-10	5-9	la1	0-4	1-3*	la1	3-5	2-5
3	5-9	5-8	3	5-9	4-9	la2	1-4	1-3	la2	3-4	3-4
4			4	5-10	6-10*	**OP**			**OP**		
5	7-12	7-10	5s	3-7	3-5	ot	15-22	15-20	ot	15-23	15-21
6s	4-7	4-7	6s	5-8	4-7	os	5-11	6-10	os	7-12	7-11
6i	8-13	8-14	6i	4-15	8-13	oi	3-6	3-6	oi	3-7	5-7
7	1	1	7	1	1	**AD**			**AD**		
b	7-11	7-11	b	6-11	6-10	n	6-9	5-10	n	8-10	7-10
d	15-19	14-20	d1	8-12	7-13	g	4-8	4-7	g	5-7	4-7
			d2	8-14	9-13	o	3-5	2-5	o	4-5	4-5
PM			**PM**			m	1	1	m	2-4	2-4
e	30-41	30-40	e	34-49	34-49	h	4-8	3-6	h	7-13*	6-14*
i	14-15	14-16	i	17-22	17-21						
por	0-2	0-2	por	2	1-2						
f	8-11	7-11	f	9-14	8-15						

Lateral-line system (Fig. 3A, Table II)

Head canals. - AOS with paired pores σ, unpaired λ and κ, paired ω, α, β and ρ present. POS absent. POC present, but only in 11 specimens on both sides complete with pores γ, δ and ε. In six adult specimens, single pores or entire POC absent; lacking pores (left, right): β(2,3), ρ(2,3), γ(5,6), δ(3,4), ε(3,4), three specimens of these six lack entire POC. One juvenile lacking pores α, β, ρ of AOS, with interorbital section still an open groove, and POC.

Sensory papillae. - As in general description and table II.

Head: PO: row c^2 in two parts, dorsal part shorter than ventral one; c_2 and c_1 longitudinal; c^1 transversal. PM: rows e and i divided at articulation of jaws into anterior (e1, i1) and posterior (e2, i2) portion; papillae of i large; in extension of i2 1-2 papillae (por) if POC absent. OS: short tr; u with two papillae between q and y (Fig. 3A) along the imaginary course of POS in all specimens.

Trunk: papillae in three series of transversal rows; ld, ltm and lv. Dorsal three transversal rows ld; ld1 and ld2 below D1 base, ld3 on caudal peduncle. Medial up to 21 transversal rows ltm along lateral midline (1-8 papillae); ltm 1-3 more separated by scales, followed by a row on each scale; no ltm on last scale. Three transversal rows lv between P origin and anus. Three longitudinal rows lc on caudal fin, medial lc2 usually the longest.

Osteology

Jaws and suspensorium (Fig. 4A, B)

Premaxilla with three processes: pointed ascending process, articular process and postmaxillar process; latter crest-like and extending to posterior end of PMX. Maxilla long and narrow, posterior end distinctly bent forward; anterior with two processes, a medial one, articulating with articular process of PMX, and a lateral one with shallow groove which receives articular process of palatine. Dentary with distinct coronoid process, posteriorly on its medial surface it receives dorsal ramus of anguloarticular and Meckel´s cartilage. Anguloarticular with dorsal and ventral ramus, anterior section of latter distinctly separated from D; articulates posterodorsal with quadrate. Retroangular small; ventromedial to articular surface of anguloarticular. Hyomandibular posterior with opercular process, dorsally two processes to sphenotic and pterotic; its inferior process slender and overlaps dorsal part of preopercle; ventrally synchondrally bound to symplectic; anterior in close contact with dorsal part of metapterygoid. Metapterygoid overlapping HY dorsally and symplectic along its posteroventral surface; synchondrally joined to quadrate; well developed anterior projection of MTP in male overlaps cartilage between MTP and quadrate and reaches posterior process of quadrate (Fig. 4B), distinctly shorter in the female, not reaching quadrate but slightly overlapping cartilage between MTP and quadrate (Fig. 4A). Symplectic strut-like, flattened and dorsally broader; posteriormost, this dorsal part extends below medial surface of MPT; no process to preopercle; ventral tip joins medial surface of quadrate. Quadrate divided in an anterior plate, dorsally extended in a short posterior process and ventrally in a long, curved extension; rostral margin of the plate attached to ectopterygoid; medial Q receives ventral tip of SY; dorsal process of plate synchondrally in contact with MPT; the curved extension in contact with horizontal part of preopercle; anteroventral articulating with anguloarticular. Preopercle curved, anterior part in contact with ventral extension of Q; dorsally overlapped by inferior process of HY; groove along its posterior margin; dorsal part anteriorly with digit-

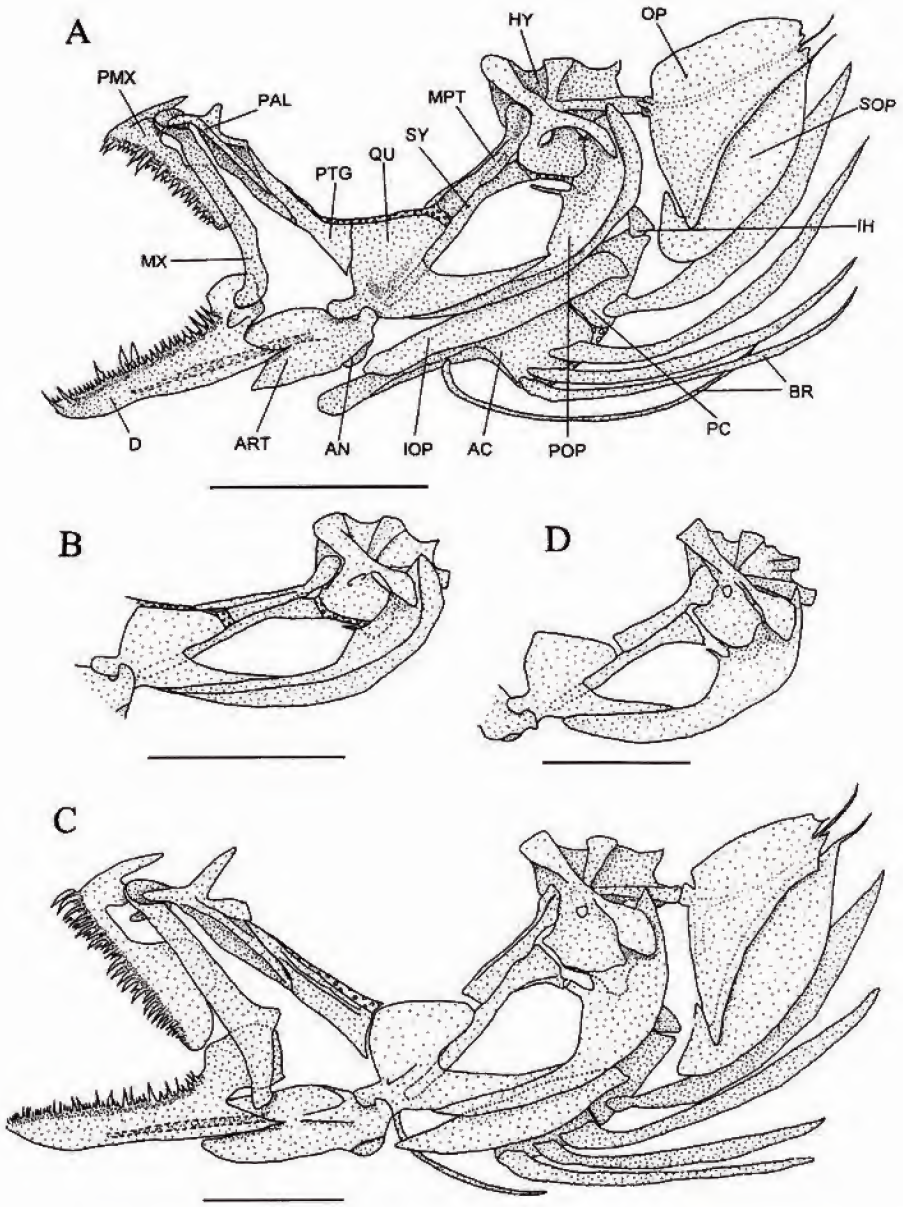

Fig. 4. - Lateral view of jaws, suspensorium, opercular series and hyoid (hypohyal not shown) or of the suspensorium, of (**A**) *Didogobius splechtnai*, IZUW 4100:10, female, 20.3 + 5.8 mm, Spain, Ibiza, Aug. 1995 (**B**) IZUW 4100:12, male, 19.1 + 5.4 mm, Spain, Ibiza, Sep. 1995; (**C**) *Gammogobius steinitzi*, IZUW 3300:6, female, 30.9 + 6.8 mm and (**D**) IZUW 3300:8, male, 36.3 + 8.0 mm, Spain, Ibiza, Sep. 1993. Cartilage is represented by small circles. Scale bar = 2 mm.

like process to SY, long and distinct in female, smaller in male (Fig. 4A, B); ventrally overlapping interopercle. Ectopterygoid, anteriorly, overlaps posterior part of palatinum; posteriorly attached to Q; cartilaginous band along its posterodorsal edge over Q to SY. Palatine anteriorly with two distinct processes; lateral maxillar process articulating with lateral process of MX, medially shorter ethmoidal process articulating with ethmoid; ventroposteriorly tightly joined to ectopterygoid.

Foramen of suspensorium bordered by ventral extension and anterior vertical margin of Q, by posterior margin of SY, digit-like symplectic process of POP (female) or short process and cartilaginous band that accompanies ventral edge of HY (male) (Fig. 4B), and by nearly ventral anterodorsal margin of POP.

Dentition

All teeth caniniform.

Upper jaw. - Premaxilla with 3-4 rows of teeth, outer row enlarged, rearwards decreasing in size; inner teeth in 2-3 series, smaller; innermost row with few slightly enlarged teeth.

Lower jaw. - Dentary near the symphysis with 4-5 enlarged teeth in an outer row, followed by 2-3 series of smaller teeth and a short innermost row which ends about half way to coronoid process of D; latter begins with 9-10 slightly enlarged teeth and ends with 2-4 distinct canines, the largest teeth in the jaws.

Hyoid and urohyal

Interhyal club-like, its dorsal end in contact with preopercle, medially with HY; ventral articulating with posterior ceratohyal. Ceratohyal divided into anterior and posterior part; anterior ceratohyal axe-shaped with four branchiostegals, anteriormost thin and rib-like; other branchiostegals becoming progressively broader and blade-like with the broadest and fifth on triangular posterior ceratohyal. Unpaired urohyal compressed, its posterior margin concave, superior tip somewhat longer than inferior. Basihyal dorsoventrally flattened, unpaired, fan-shaped, anterior margin cartilaginous.

Opercular series

Preopercle: see jaws and suspensorium. Opercle nearly triangular, its posteroventral edge slightly concave, overlapping subopercle posteriorly and ventrally; hyomandibular process bearing a small, slender, vertical process. Opercle and hook-shaped subopercle with thin projections from their dorsal rims. Interopercle strut-like, dorsally overlapped by POP.

Pectoral girdle (Fig. 5A)

Posttemporal with a dorsal and ventral process and a laminar body, the latter overlapping the articulation to supracleithrum; no groove on central body. Supracleithrum bar-like, extends from medial surface of central body of PT to dorsolateral portion of cleithrum. Cleithrum forked dorsally; in middle area bony flanges join pelvic intercleithral cartilage; between ventrally joined arms of cleithra ventral intercleithral cartilage. Coracoid axe-shaped, with posterior process, anteriorly inserting with its narrow part into CL. Scapula completely unossified, elongated; with large dorsal foramen; joins CL anteriorly and dorsally, COR ventrally, posteriorly with four radials. Four large, laterally flattened proximal radials, bordered anteriorly, dorsally and posteriorly by cartilage which extend between the radials. Distal radials cartilaginous.

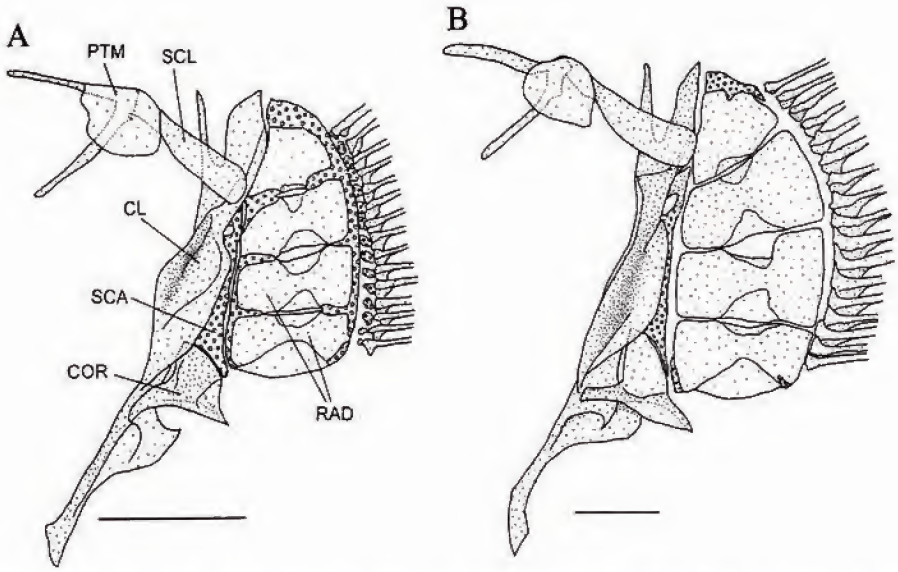

Fig. 5. - Pectoral girdle (lateral view) of (**A**) *Didogobius splechtnai*, IZUW 4100:12, male, 19.1 + 5.4 mm, Spain, Ibiza, Sep. 1995 and (**B**) *Gammogobius steinitzi*, IZUW 3300:8, male, 36.3 + 8.0 mm, Spain, Ibiza, Sep. 1993. Cartilage is represented by small circles. Scale bar = 1 mm.

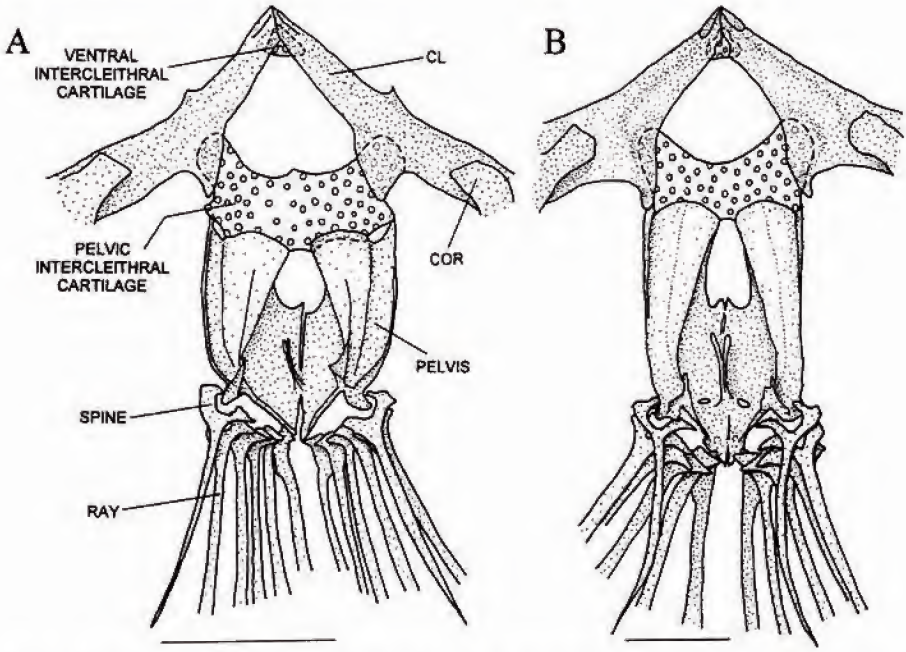

Fig. 6. - Pelvic girdle (ventral view) of (**A**) *Didogobius splechtnai*, IZUW 4100:10, female, 20.3 + 5.8 mm, Spain, Ibiza, Aug. 1995 and (**B**) *Gammogobius steinitzi*, IZUW 3300:8, male, 36.3 + 8.0 mm, Spain, Ibiza, Sep. 1993. Cartilage is represented by small circles. Scale bar = 1 mm.

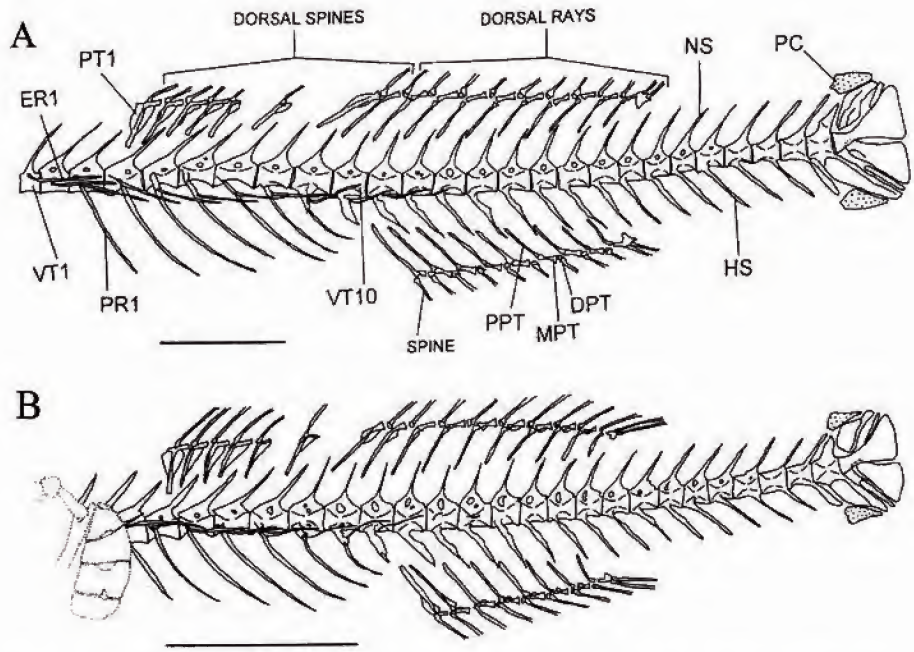

Fig. 7. - Vertebrae and unpaired fins of (**A**) *Didogobius splechtnai*, IZUW 4100:12, male, 19.1 + 5.4 mm, Spain, Ibiza, Sep. 1995 and (**B**) *Gammogobius steinitzi*, IZUW 3300:8, male, 36.3 + 8.0 mm, Spain, Ibiza, Sep. 1993. Procurrent cartilage stippled. Scale bar = 2 mm.

Pelvic girdle (Fig. 6A)

Large unpaired pelvic intercleithral cartilage joined anteriorly to medial flanges of CL and posteriorly to pelvic bone. Pelvis laterally with cone-like core that joins anteriorly pelvic intercleithral cartilage, each posterolateral edge with process on which large base of pelvic spine articulates; shorter medial part dorsally convex, less substantial, with digit-like processes that diverge near their tips.

Vertebrae and unpaired fins (Fig. 7A)

Vertebrae. - 27 (10+17), including urostyle. 10 precaudal and 17 caudal vertebrae. VT11 first caudal vertebra with first hemal arch. 12 epipleural ribs on vertebrae 1 to 12, last three epipleural ribs lying in connective tissue without attachment to vertebrae or pleural ribs. First epipleural rib attached to VT1, second to parapophysis of VT2, ER3 to ER9 to pleural ribs. 7 pleural ribs, attached to corresponding parapophyses of VT3 to VT9. Parapophyses of VT7 to VT10 becoming progressively larger. Hemal arches of vertebrae 11 to 23 arise from the anterior part of the vertebral body, the following arches from posterior part. Hemal arch of VT24 with a slender hemal spine, as in the preceding vertebrae. VT25 with slightly modified, spatula-like hemal spine. VT26 with modified neural and hemal arches. HS26 broad and elongated, with cylindrical strut on posterior margin and anterior bony flange, the latter reaching ventral procurrent cartilage. Neural spines thin and pointed; arising from about middle of vertebral body, from about NS22 arising progressively more posteriorly.

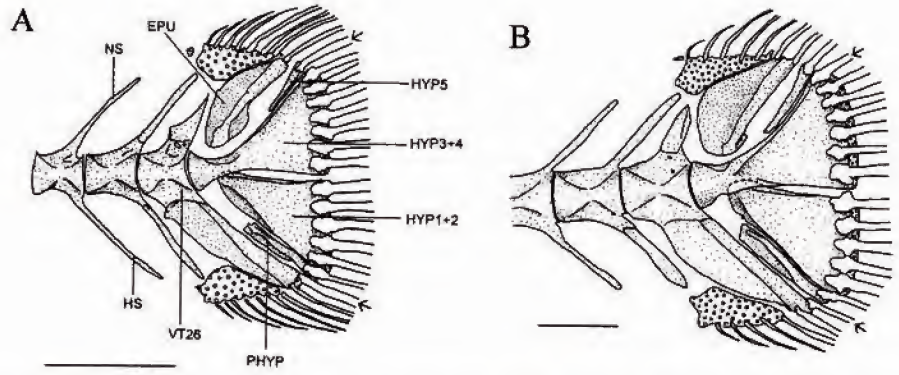

Fig. 8. - Caudal skeleton of (**A**) *Didogobius splechtnai*, IZUW 4100:12, male, 19.1 + 5.4 mm, Spain, Ibiza, Sep. 1995 and (**B**) *Gammogobius steinitzi*, IZUW 3300:8, male, 36.3 + 8.0 mm, Spain, Ibiza, Sep. 1993. Arrows indicate first, respectively last segmented branched ray. Scale bar = 1 mm.

Unpaired fins. - Dorsal PT formula 3-221101: three neural spines before first PT; first two pterygiophores insert into third interneural space, third and fourth into fourth, fifth into fifth, and sixth into sixth interneural space; no PT inserts into seventh interneural space and first of D2 inserts into eighth.

First dorsal fin: PT fused to single element, each articulating with one of the six spines.

Second dorsal fin: spine and first ray supported by a proximal and a distal pterygiophore each; medial PT apparently lost or fused to proximal PT. Succeeding rays supported by tripartite pterygiophores with proximal, medial and distal elements. All distal PT cartilaginous. Last two rays (counted as one) supported by one proximal and one axe-like medial PT; this last proximal PT inserts into seventeenth interneural space.

Anal fin: Spine articulating with proximal PT of first ray. First ray lacking medial PT. Rays 2-8 with proximal, medial and distal PT. Last two rays (counted as one) lacking distal PT; medial PT axe-like. First two PT fin insert before first hemal arch (between vertebra 10 and 11).

Caudal skeleton (Fig. 8A)

Modified NS and HS of VT25 and HS26 supporting caudal fin. Single large epural; posterior margin strut-like; anterior margin flat, in close contact to procurrent cartilage; small, splint-like hypural 5; fan-shaped hypural 3-4, fused to centrum of VT27; fused hypural 1-2 forming a single plate, inserting into groove on ventral side of ural centrum; parhypural with slender cylindrical core and thin bony ventral blade.

6-7 dorsal (7: male, 6: female) and ventral (6: male, 7: female) unsegmented procurrent rays, both supported by procurrent cartilage. One segmented unbranched ray on epural. One segmented branched ray on HYP 5, seven on hypural 3-4, six on hypural 1-2 (last ray overlapping parhypural). One segmented branched ray and one segmented unbranched ray on cylindrical strut of HS26.

Fig. 9. - *Gammogobius steinitzi*, IZUW 3300:18, male, 28.0 + 6.5 mm, Spain, Ibiza, Punta Mares; 8m; 23 Sep. 1997. Scale bar = 10 mm.

GAMMOGOBIUS STEINITZI BATH, 1971
(Fig. 9)

Material
17 specimens; 5 males, 10 females and 2 juveniles.
See Scsepka and Ahnelt (in press).

General description
Gammogobius steinitzi differs from all other Mediterranenan gobiids in its combination of the following characters: (1) short, tubular anterior nostril, not reaching upper lip when depressed; no process from rim, (2) AOS present; POS and POC absent, (3) seven transversal rows; 4 rows before, two above and one below b; rows 1, 2, 3 and 4 before longitudinal row b, 5s and 6s short, dorsal of b; 6i ventral of b; row 7 represented by one papilla near pore α, (4) longitudinal row d divided; anterior d1 along posterior margin of upper lip and (5) head and breast naked; predorsal of D1 origin with a few small scales; body with ctenoid and a few cycloid scales.

Tip of urogenital papilla in females broad, thickened during spawning season; in males elongated and narrow.

Sexual dimorphism exists in abdomen length and upper jaw length. Body proportions are given in table III.

Fins
D1 VI (17), D2 I/8-9 (8:4, 9:13), A I/8 (17), C 13-15 (13:8, 14:6, 15:2, d:1), P 15-17 (15:1, 16:15, 17:1), V I/5+5/I (17).

First spines of D1 not elongated; interdorsal space distinct; A originates posterior of vertical through D2 origin; C rounded; uppermost rays of P not free from membrane; V rounded to slightly emarginate and originates posterior of P origin; well developed fraenum.

Scales (Fig. 2B)
Predominantly ctenoid; two patches of cycloid scales, one dorsal of P and the other ventral from origin of P to AN, a few small scales may occur anterior of V origin. Head naked. LL 31-37 (31:1, 32:1, 33:4, 34:4, 35:4, 36:1, 37:1). TR 9-11 (9:1, 10:8, 11:7)

Coloration (Fig. 9)
As in Scsepka and Ahnelt (in press).

Lateral-line system (Fig. 3B, Table II)
Head canals. - AOS with paired pores σ, unpaired λ and κ, paired ω, α, β and ρ present; POS and POC absent. Additional pores in four adult specimens: between furcation to σ-pores and λ (n = 1), between ω and α (n = 1, right), between α and β (n = 2, right). One juvenile with AOS incomplete, lacking horizontal part behind α; but two primary neuromasts already developed.

Table III. - Body proportions of *Gammogobius steinitzi* from Ibiza. Values are ranges, means (m) and standard deviations (s).

Sex		Males			Females		
n		4			9		
SL (mm)		25.1-36.3			21.7-30.9		
		ranges	m	s	ranges	m	s
%SL	H	30.2-33.7	32.6	1.6	31.0-33.6	32.3	0.7
	Hw	12.4-14.4	13.3	0.8	11.8-14.7	13.0	0.8
	SN/D1	39.2-42.1	40.4	1.1	40.1-42.7	41.4	0.8
	SN/D2	57.4-59.5	58.4	0.8	57.7-60.9	59.1	0.9
	SN/AN	53.1-55.1	54.3	0.7	54.1-56.9	55.7	1.0
	SN/A	59.0-60.2	59.6	0.5	59.5-62.2	60.7	0.9
	SN/V	31.5-34.3	33.1	1.1	31.9-33.5	32.7	0.5
	CP	26.0-26.4	26.2	0.1	25.0-27.1	25.7	0.7
	D1b	11.3-11.9	11.6	0.3	11.0-11.8	11.4	0.3
	D2b	18.0-20.8	19.8	1.1	19.1-21.3	20.0	0.6
	Ab	15.7-16.4	16.1	0.3	14.6-15.6	15.4	0.6
	Cl	21.9-23.3	22.5	0.5	20.9-24.0	22.8	1.0
	Pl	23.8-25.2	24.4	0.6	24.9-27.6	26.7	0.8
	Vl	23.1-25.4	24.4	0.9	23.2-27.0	25.0	1.1
	Vd	17.3-18.6	18.0	0.5	16.6-19.0	17.8	0.7
	Ad	15.7-17.5	16.6	0.7	15.2-16.6	15.8	0.4
	Aw	10.2-11.5	10.7	0.5	8.4-9.6	9.2	0.3
	CPd	9.6-10.5	10.1	0.4	8.9-10.2	9.5	0.5
	V/AN	20.5-23.4	22.2	1.1	21.9-25.1	23.7	1.0
% CP	CPd	36.5-40.0	38.8	1.4	33.8-40.4	37.1	2.2
% H	SN	27.7-31.3	29.1	1.3	28.5-31.0	29.8	0.8
	E	27.4-30.8	28.7	1.3	27.7-32.1	29.7	1.4
	PO	40.9-45.9	43.9	2.0	41.1-46.3	42.8	1.9
	CHd	19.3-22.3	20.2	1.2	17.4-19.6	18.1	0.7
	Hw	38.2-45.4	41.0	3.0	36.7-43.7	40.1	2.3
	UJ	34.0-39.7	37.1	2.0	33.1-36.6	35.2	1.1
% E	I	11.1-15.9	13.0	1.8	9.1-14.4	11.7	2.0
% V/AN	Vl	103.3-123.9	111.0	7.9	101.8-108.1	105.4	2.3

Sensory papillae. - As in general description and table II.

Head: PO: row c^2 in two longitudinal, parallel parts. PM: rows e and i divided at articulation of jaws into anterior (e1, i1) and posterior (e2, i2) portion; papillae of i large; i2 mostly starting with two transverse papillae; in extension of i2 1-2 papillae (por) more distant from each other than papillae of remaining row i. OS: distinct tr; u with up to two papilla between rows q and y (Fig. 3B), in three specimens anterior part of u consists of 2-3 transverse papillae, only on one side.

Trunk: as in *D. splechtnai* except ld2 below posterior part of D2; ltm 19-21 rows (2-11 papillae), ltm2 and ltm3 longest; 8 specimens (n = 16) without ltm on last scale on both sides.

Osteology

Jaws and suspensorium (Fig. 4C, D)

Premaxilla with three processes: pointed ascending process, articular process and postmaxillar process; latter crest-like, high and ending before posterior margin of PMX. Maxilla long, width posteriorly slightly increasing; with process from dorsal margin; proximal end not bent forward; anteriorly with two processes, a medial one articulating with articular process of PMX and a lateral one with shallow groove which receives articular process of palatine. Dentary with large coronoid process, posteriorly on its medial surface it receives dorsal ramus of anguloarticular and Meckel´s cartilage. Anguloarticular with dorsal and ventral ramus, the latter long and in close contact with D; articulates posterodorsally with quadrate. Hyomandibular posterior with opercular process, dorsally two processes to sphenotic and pterotic; its inferior process broad and overlaps dorsal part of preopercle; ventrally synchondrally bound to symplectic; anteriorly in close contact with dorsal part of metapterygoid. Metapterygoid overlapping HY dorsally and symplectic along its posteroventral surface; no bridge or cartilaginous junction to quadrate. Symplectic strut-like, flattened and dorsally broader; posteriormost, this dorsal part extends below medial surface of MPT; process to preopercle in male (Fig. 4D), less distinct in female (Fig. 4C); ventral tip joins medial surface of quadrate. Preopercle curved, anterior part in contact with ventral extension of Q; dorsally overlapped by inferior process of HY; narrow groove along its posterior edge, not visible in lateral view; dorsal part anteriorly with digit-like process to SY, less distinct in female (Fig. 4C); ventrally overlapping interopercle. Ectopterygoid, anteriorly, overlaps posterior part of palatinum and is posteriorly attached to Q; cartilaginous band along its posterodorsal edge to Q.

Retroangular, quadrate and palatine as in *D. splechtnai*.

Foramen of suspensorium bordered by ventral extension and anterior vertical margin of Q, by posterior margin of SY and its variably developed preopercular process, by symplectic process of POP and nearly vertical anterodorsal margin of POP.

Dentition

All teeth caniniform.

Upper jaw. - Premaxilla with a row of 5-6 enlarged teeth, rearwards decreasing in size and positioned slightly closer; inner teeth in 3-4 poorly defined series of smaller teeth; innermost ones may be somewhat enlarged.

Lower jaw. - Dentary near the symphysis with 5-6 enlarged teeth in an outer row, followed by about 3 poorly defined series of smaller teeth and a innermost row with more than 20 teeth, rearwards enlarged.

Hyoid and urohyal
As in *Didogobius splechtnai.*

Opercular series
Preopercle: see jaws and suspensorium. Opercle nearly triangular, its posterior-ventral edge slightly concave, overlapping subopercle posteriorly and ventrally, anteriorly process articulating with HY. Opercle and hook-shaped subopercle with thin projections from their dorsal rims. Interopercle blade-like, tipped anterior end; dorsally overlapped by POP.

Pectoral girdle (Fig. 5B)
Posttemporal, supracleithrum, cleithrum and coracoid as in *Didogobius splechtnai*; except scapula, which is completely unossified in female, part dorsal of foramen ossified in male (Fig. 5B); proximal radials not distinctly bordered by cartilage. Distal radials cartilaginous.

Pelvic girdle (Fig. 6B)
As in *Didogobius splechtnai.*

Vertebrae and unpaired fins (Fig. 7B)
Vertebrae. - 27 (10+17), including urostyle. 10 precaudal vertebrae and 17 caudal vertebrae. 11-12 (11: female, 12: male) epipleural ribs, on vertebrae 1 to 11 respectively 12; posteriormost epipleural ribs very small and lying free in the connective tissue. First epipleural rib articulates on very small parapophysis. Parapophyses of VT1 to VT3 progressively larger, of same size to VT7 and larger again and positioned more ventrally to VT10. 7 pleural ribs in female, associated with VT3 to VT7; 9 pleural ribs in male, associated with VT2 to VT10. VT11 first caudal vertebra, succeeding hemal arches becoming more slender. Hemal arches of VT12 to V22 arise from anterior part of the vertebral body, subsequent ones from posterior part. NS25 and, more distinct, HS25 broader than previous. HS26 broad and elongated; with cylindrical strut on posterior margin and distinct anterior bony flange, latter reaching ventral procurrent cartilage and bearing one segmented ray and one segmented, branched ray. Neural spines thin and pointed, arising from about the middle of the vertebral body, from about NS22 arising progressively more posteriorly.

Unpaired fins. - Dorsal PT formula 3-221101. First and second dorsal fins: as in *D. splechtnai* except D2 with 9 rays and therefore last proximal PT inserting into sixteenth interneural space in both sexes. First five pterygiophores of D2 inserting solitarily into interneural spaces, PT six and seven into thirteenth interneural space in male specimen; in female first six PT inserting solitarily, PT seven and eight inserting into fourteenth interneural space.

Anal fin: as in *D. splechtnai* except with one ray less.

Caudal skeleton (Fig. 8B)
As in *D. splechtnai* except NS and HS of VT26 less modified; epural broader and hypural 5 longer.

6-7 dorsal (6: male, 7: female) and 5 ventral, unsegmented procurrent rays, supported by procurrent cartilage; posteriormost dorsal procurrent ray inserting into anterior flange of epural in male. One segmented, unbranched ray on cylindrical strut of epural.

One segmented, unbranched ray on HYP5, seven segmented, branched rays on HYP3+4, five on HYP1+2 and one on parhypural. One segmented, branched and one segmented, unbranched ray on cylindrical strut of HS26.

DISCUSSION

The genera *Didogobius* and *Gammogobius* are considered to be related to a group of north-eastern Atlantic-Mediterranean gobiid forms with suborbital transverse arrangement of sensory papillae and a combination of the following plesiomorphic features: (1) canals of the head lateral-line system completely developed with AOS, POS and POC, (2) seven transverse suborbital papillae rows, four before the longitudinal row b and two divided by b into superior and inferior sections, (3) row 7 represented by several papillae, (4) ctenoid scales, (5) uppermost rays of P free from membrane and (6) anterior nostril tubular, with tentacle from rim (Miller, 1966, 1977, 1992).

D. splechtnai and *G. steinitzi* are both synapomorphic in (1) loss of POS, (2) only one sensory papillae row below b, (3) row 7 represented by single papilla only, (4) tendency towards loss of scale ctenii, (5) uppermost rays of P not free from membrane and (6) anterior nostril without tentacle from rim. In these characters both species seem to represent a derived condition which may have evolved with the specialized mode of life as cave-dwellers.

Nevertheless, each also displays apomorphic and plesiomorphic features which are not found in the other. These morphological characteristics, most obvious in the lateral-line system and the osteology, are summarized as follows (data of *G. steinitzi* in parentheses): (1) POC present to completely lacking, por of 0-2 papillae (POC absent in all specimens, por of mostly 2 papillae), (2) six transversal suborbital rows of papillae (seven rows), (3) row 5 long and undivided, reaching longitudinal row d (row 5 short, with only 5s developed), (4) continuous row d (d divided), (5) 2 papillae of u (1-3 papillae), (6) cycloid scales on a wider area of the body (only a few cycloid scales) (Fig. 2), (7) a rather small metapterygoid bridge as well as a symplectic process of the preopercle but no preopercular process of the symplectic (no metapterygoid bridge; symplectic process of the preopercle and preopercular process of symplectic present) (Fig. 4).

If one follows the argumentation that loss of transversal suborbital rows of sensory papillae represents a derived state (Miller, 1972), then *D. splechtnai* is more specialized than *G. steinitzi*. This is supported by the pronounced trend towards loss of ctenii.

On the other hand most *D. splechtnai* possesses POC and a distinct groove along the posterior edge of the preopercle; *G. steinitzi*, however merely has a narrow groove at the POP, as it possesses no POC at all (Fig. 4).

In all osteologically examined species of north-eastern Atlantic-Mediterranean gobiids there is a well-developed connection from the metapterygoid to the quadrate as well as between symplectic and preopercle (Miller, 1977; Harrison, 1989). Each of the two examined species here has reductions in these features that are not found in the other (Fig. 4) and for which sexual dimorphism and differences between individuals are known (Birdsong, 1975; Springer, 1983; Harrison, 1989). The latter is possibly also the case in *D. splechtnai* and *G. steinitzi*: in *D. splechtnai* the metapterygoid bridge is more prominent in the female, whereas for the symplectic process of the preopercle this is the case in the male. In *G. steinitzi*, where both sexes lack a metapterygoid bridge, the symplectic preopercle connection is more prominent in the male.

The differences in the remaining osteological features include: (1) number and position of enlarged canine teeth; this may be due to different prey types, but no data on the diet of either species is available. (2) The scapula in both species is cartilaginous and large and, as in the Gobiinae, its foramen is never enclosed by bone (individual variation is described (Akihito, 1986)). This is displayed in *G. steinitzi*, where the scapula in the female is completely cartilaginous, yet dorsally ossified in the male (Fig. 5). (3) In *D. splechtnai* the radials are rimmed by cartilage perhaps due to its small size (Van Tassell, 1988). (4) Supporting elements of the dorsal and ventral procurrent cartilage are more distinctly developed in *G. steinitzi*, especially the large anterior flanges of HS26 and EPU and NS and HS of VT25; HYP5 and PHYP larger than in *D. splechtnai* (Fig. 8).

Finally, both species differ in the shape and position of the ventral disc. It is more emarginate with a less well-developed fraenum and is positioned further anterior in *D. splechtnai*. The Splechtna goby occurs on the bottom of caves on fine sediment, whereas the Steinitz goby occupies the walls.

Both species have 10+17 vertebrae, which corresponds among the eastern Atlantic-Mediterranean gobiids to the plesiomorphic type (Miller, 1992). (*D. bentuvii* shows 28 vertebrae, presumably in accordance with body elongation.) With a 3-22110 DI pterygiophore insertion pattern and two prehemal PT (Fig. 7), both show typical gobiine features (Pezold, 1993).

D. splechtnai is clearly morphologically more specialized because of the lower number of transversal suborbital papillae rows and more massive losses of scale ctenii.

However, both species display plesiomorphic and apomorphic features. Nonetheless, the apomorphic features appear to be more dependent on small body size and adaptation to cryptobenthic life than representing phylogenetic trends.

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Reçu le 28.12.1998.
Accepté pour publication le 04.05.1999.